

(4)

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification<sup>6</sup>:

B21C 37/15, 23/10

A1

(11) International Publication Number:

WO 00/23205

(43) International Publication Date:

27 April 2000 (27.04.00)

(21) International Application Number: PCT/NL98/00603

(22) International Filing Date: 20 October 1998 (20.10.98)

(71) Applicant (for all designated States except US): REYNOLDS  
ALUMINIUM HOLLAND B.V. [NL/NL]; P.O. Box 30,  
NL-3840 AA Harderwijk (NL).

(72) Inventor; and

(75) Inventor/Applicant (for US only): BAKKER, Harmen  
[NL/NL]; Zeestraat 59I, NL-3841 JL Harderwijk (NL).(74) Agent: DE BRUIJN, Leendert, C.; Nederlandsch Octrooibu-  
reau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS  
The Hague (NL).

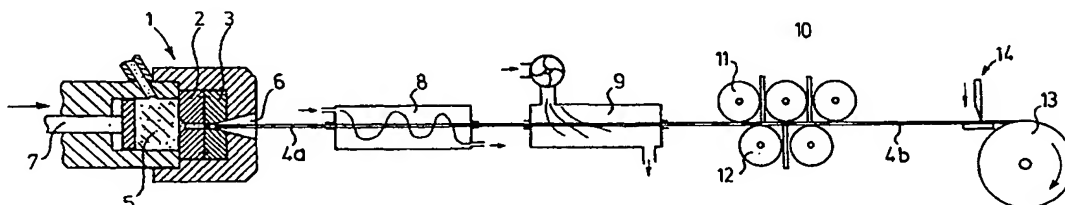
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR,  
BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD,  
GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR,  
KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN,  
MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK,  
SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW,  
ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW),  
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,  
GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF,  
BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN,  
TD, TG).

Published.

With international search report.

In English translation (filed in Dutch).

(54) Title: METHOD FOR THE PRODUCTION OF MULTI-CHANNEL TUBES; MULTI-CHANNEL TUBES OBTAINED IN THIS  
WAY; AND AN EXTRUSION DIE AND INSTALLATION FOR CARRYING OUT THE METHOD



## (57) Abstract

The invention relates to a method for the production of multi-channel tubes, in particular flat multi-channel tubes, which comprises a first and a second step. The first step is forming, by means of extrusion, a tube having on the inside a multiplicity of ribs extending in the longitudinal direction of the tube, projecting from the inside wall of the tube and having free ends. The second step is compressing the extruded tube to bring the free ends of the internal ribs to close to, preferably in contact with, an opposing interior part of the tube such that a multiplicity of interior channels are formed in the tube. Step b) can be carried out stepwise in several steps. Preferably one or more mandrels are used for the extrusion, which mandrels essentially consist of a solid component with grooves formed in the circumferential surface thereof, which grooves have a base extending in the extrusion direction. The invention also relates to a multi-channel tube obtained using the method according to the invention and to an extrusion die and an installation for carrying out the method according to the invention.

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakistan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Method for the production of multi-channel tubes; multi-channel tubes obtained in this way; and an extrusion die and installation for carrying out the method

The present invention relates to a method for the production of multi-channel tubes, in particular flat, multi-channel tubes.

Methods of this type are known. As is also known, with these methods problems arise in particular when it is desired to make very small multi-channel tubes. In this context very small multi-channel tubes are in particular understood to be multi-channel tubes of which the interior channels have very small dimensions. When such multi-channel tubes having very small dimensions for the channels have to be produced by extrusion, that is to say by an extrusion method in which the tube core delimiting the multiplicity of channels is co-extruded with the tube, in the case of the techniques known from the prior art the problem arises that use has to be made of a mandrel having a pin-like mandrel section of very small dimensions per channel. With regard to an extrusion mandrel of this type reference can be made, for example, to European Patent Application EP 0 595 061. It will be clear that in extrusion processes, in particular processes in which a metal, such as an aluminium or an aluminium alloy, is extruded, extrusion mandrels of this type having very thin pin-like mandrel sections are highly susceptible to wear and, moreover, as a consequence of the very small cross-sectional dimensions of the pin-like mandrel sections are highly vulnerable. The minimum channel size achievable in the case of such multi-channel tubes to be produced by extrusion is therefore also restricted in practice to channels having internal dimensions of at least 0.45 mm.

The aim of the present invention is to provide a method for the production of tubes having a multiplicity of channels integrally formed at the same time, in particular flat multi-channel tubes, wherein the channels can assume very small internal dimensions and wherein, in particular, the extrusion mandrel required for the extrusion can also have a long tool life and high resistance to wear.

The abovementioned aims are achieved according to the invention by the provision of a method for the production of multi-channel tubes, in particular flat multi-channel tubes, which comprises the following steps:

- a) forming, by means of extrusion, a tube having on the inside a multiplicity of ribs extending in the longitudinal direction of the tube, projecting from the

inside wall of the tube and having free ends;

- b) compressing the extruded tube to bring the free ends of the internal ribs close to, preferably in contact with, an opposing interior part of the tube such that a multiplicity of interior channels are formed in the tube.

5 By, during the extrusion, forming a tube which has ribs freely projecting into the interior, that is to say ribs where one end integrally merges into the inside wall and the other free end is freely located in the interior of the tube and thus does not merge into another part of the inside wall of the tube, the extrusion mandrel is not subject to the requirement that it has a separate pin-like mandrel section per channel, but, for  
10 example, a plate-shaped mandrel section can suffice, one or both opposing plate sections of which are provided with grooves having a depth less than the thickness of said plate section. The mechanical strength, stability, the tool life and the resistance to wear of such an extrusion mandrel, which thus consists of an essentially solid plate section instead of a multiplicity of separate individual pins, are appreciably better than  
15 in the case of an extrusion mandrel having a multiplicity of individual pins. The actual shaping of the multiplicity of channels then takes place in step b) by compressing the tube having ribs freely projecting into the interior, extruded in step a), in order to bring the free ends of the freely projecting ribs into contact with an opposing interior part of the tube or at least to very close to an opposing interior part of the tube, as a  
20 result of which the ribs, which were still freely projecting in step a), become, as it were, webs extending between interior parts, each of which webs forms a boundary wall for the multiplicity of channels. It will be clear that a multiplicity of techniques are conceivable for the compression. The tube section extruded in step a) can, for example, be clamped in an essentially immobile position between two press  
25 components movable with respect to one another and compressed. It will, however, be preferred if the compression takes place while still in the extrusion line, which, for example, can be achieved by compressing the extruded tube section while this is still on the run-out part of the extrusion line, which is frequently also referred to as the run-out table, for example by feeding said extruded tube section between one or more  
30 sets of rollers.

The method according to the invention can in particular suitably be used for the extrusion of aluminium or an aluminium alloy.

In a particular embodiment of the method according to the invention it has

proved highly advantageous when a die comprising an extrusion passage defining the outer circumference of the tube and a mandrel defining the internal circumference and internal ribs of the tube is used for the extrusion in step a), wherein the mandrel comprises an essentially solid component with, in the circumferential surface transverse to the extrusion direction, the projecting ribs with free ends determining grooves having a base extending in the extrusion direction. In general, an extrusion die of this type will consist of a female die section provided with the extrusion passage and a male die section provided with the mandrel. During extrusion the mandrel will project into the extrusion passage. Instead of one mandrel it is possible to use various mandrels.

In order to prevent the final multi-channel tube becoming damaged during compression of the tube formed in step a), it is advantageous according to the invention if step b) is at least partially and in particular predominantly carried out at a tube temperature below 600 °C.

With the method according to the invention, the compression will advantageously take place stepwise in several, at least two, steps. Specifically, this makes it possible, in particular, to perform the compression in a regulated, controllable manner. Prior to a previous compression step and after said previous compression step, or possibly only after the previous compression step, the thickness of the tube formed up to that point is then measured, which gives an indication of the compression to be achieved in the subsequent step, which can then be adjusted depending on the previously measured result, for example by varying the compressive force.

So that the compression can still take place in the extrusion line at a temperature appreciably lower than the extrusion temperature, because damage to the multi-channel tube ultimately to be formed must be prevented, it is advantageous according to the invention if the extruded tube is cooled between step a) and step b) with a liquid, such as water, and/or a gas, such as air. In this context it is also readily possible in the case of stepwise compression for the extruded tube to be cooled between two successive compression steps or between all successive compression steps. It is even possible to compress the extruded tube during cooling. The final step can then be carried out at 20 °C.

Using the method according to the invention it proves to be possible, in a highly advantageous manner, to form multi-channel tubes, in particular flat multi-

channel tubes, having very small channels and channel wall dimensions. In this context, according to the invention it is particularly advantageous

- if flat multi-channel tubes are formed which contain channels up to, for example, 0.1 mm in size having a width of less than 0.75 mm;
- 5 - the thickness of the projecting ribs is formed less than 2 mm, preferably less than 0.3 mm, such as, for example, approximately 0.15-0.05 mm;
- the height of the projecting ribs is made less than 6 mm, preferably less than 0.6 mm, for example 0.2 mm.

With the method according to the invention it has proved particularly  
10 advantageous if the internal thickness of the tube formed in step a) is taken larger than the height by which the projecting ribs project with respect to the inside wall in the tube formed in step a). In this context it has proved particularly advantageous if the internal thickness of the tube is taken, for example, 10 - 60 % greater than the height by which the ribs project in the internal thickness direction with respect to the inside  
15 wall. It has also proved advantageous if the internal thickness of the tube and the height, seen in the thickness direction, by which the projecting ribs project with respect to the inside wall is chosen such that a reduction in the internal thickness of the tube of at most 70 % and preferably approximately 50 % takes place during compression.

According to a further embodiment of the method according to the invention,  
20 two tubes joined to one another by a connecting web are formed by extrusion in step a), at least one of said tubes having, on the inside, a multiplicity of said projecting ribs with free ends and being subjected to step b). In this way it is possible, in particular for vehicles, to produce the multi-channel tubes for the radiator and the condenser for the air conditioning joined together in a single procedure, which leads to lowering of  
25 the production costs. Especially if the connecting web has a short length, it is also possible in this way to make the condenser for the air conditioning and the radiator for a vehicle of very compact construction with the product finally obtained. If the compact construction is of lesser importance, it is then optionally possible to separate the two tubes produced by one procedure from one another by subsequently cutting  
30 through the connecting web. It will be clear that this method can, in principle, also be used entirely separately from the compression and therefore, as it were, constitutes a second aspect of the invention. According to a second aspect of the invention, the invention therefore also relates to a method for the simultaneous forming of a multi-

channel condenser tube for an air conditioning system and a multi-channel tube for a radiator for a vehicle, wherein the two multi-channel tubes are formed integrally with a connecting web present between them in a single extrusion process. According to this second aspect of the invention, the invention also relates to a set of two multi-channel tubes connected by a connecting web formed in one piece with the multi-channel tubes.

According to the first aspect, the present invention further also relates to a multi-channel tube, in particular a flat multi-channel tube, obtained by the method according to the invention. In this context the invention in particular also relates to a multi-channel tube, in particular a flat multi-channel tube, made of aluminium or an aluminium alloy for evaporators, condensers and radiators of, in particular, vehicles, which multi-channel tube is obtained by the method according to the invention.

According to the first aspect, the invention furthermore also relates to an extrusion die for forming, by extrusion, a tube having ribs, with free ends, projecting on the inside, comprising an extrusion passage defining the outer circumference of the tube and a mandrel defining the interior circumference and interior ribs of the tube, wherein the mandrel comprises an essentially solid component with, in the circumferential surface transverse to the extrusion direction, grooves having a base extending in the extrusion direction which define the projecting ribs with free ends. Additional mandrels can be present if needed.

According to the first aspect of the invention, the latter furthermore also relates to an installation for carrying out the method according to the first aspect of the invention, comprising an extrusion press installation having an extrusion die according to, preferably, Claim 15 and compression means. In said installation the compression means are preferably located downstream of the extrusion die. The compression means can comprise, for example, one or more sets of rollers. The latter can be arranged straight above one another and are adjustable in any conceivable manner.

The present invention will now be explained in more detail below with reference to an illustrative embodiment shown diagrammatically in the drawing. In the drawing:

Fig. 1 shows, highly diagrammatically, an extrusion installation and adjoining run-out line according to the invention for carrying out the method according to the invention;

Figs 2A and 2B show a perspective view of an extrusion die according to the invention and for use with the method according to the invention;

Fig. 3 shows a perspective view of a detail of the mandrel of the extrusion die in Fig. 2, in particular the mandrel of the die section in Fig. 2B;

5 Fig. 4 shows a cross-sectional view of an example of an extrusion profile obtained according to the method of the invention, Fig. 4A showing the profile immediately after the extrusion step and Fig. 4B showing the profile after the compression step(s);

10 Fig. 5 shows a further example, in cross-section, of an extrusion profile according to the invention, Fig. 5A again showing the extrusion profile immediately after the extrusion step and Fig. 5B the extrusion profile after the compression step(s);

Fig. 6 shows, in cross-section, yet a further illustrative embodiment of an extrusion profile according to the invention, Fig. 6A showing the extrusion profile immediately after the extrusion step and Fig. 6B the extrusion profile after the  
15 compression step(s);

Fig. 7 shows, in cross-section, yet a further illustrative embodiment of an extrusion profile according to the invention;

Fig. 8 shows a diagrammatic perspective view of a compression installation for compressing a previously extruded multi-channel tube; and

20 Fig. 9 shows a variant of a compression installation which in other respects corresponds to Fig. 8.

Fig. 1 shows, diagrammatically, the set-up of a production line for carrying out the method according to the invention. The ram extruder installation, comprising extrusion die sections 2 and 3, a ram 7 and an extrusion orifice 6, is indicated by 1.  
25 The so-called billet of material to be extruded is indicated by 5.

The billet is extruded to produce a tubular extrusion profile 4a, which undergoes a change in shape as it passes through the installation and, following said change in shape, is indicated at the end by 4b. In the case of aluminium extrusion, the extrusion profile 4a generally leaves the extrusion orifice 6 at a temperature of the  
30 order of magnitude of about 600 °C and, for accelerated cooling, is fed through a cooling installation 8 containing a water bath through which the profile is fed. After leaving the water cooling installation 8, the extrusion profile is fed through an air cooler 9, which feeds a forced stream of air over the extrusion profile in order to cool



this further but, in particular, also to dry it. In conventional extrusion processes, the extruded profile is then cut to size with the aid of a travelling knife or travelling scissors or is wound onto a roll with the aid of a winding installation.

5 In accordance with the method according to the invention, the extrusion profile is, however, also fed through a compression installation 10 in order substantially to compress the extrusion profile, in which context substantial compression must be considered as a reduction in the external thickness of the order of magnitude of at least 10 %, in general 20 % or more and frequently even 30 % or more. After the profile has been fed through the compression installation 10, it is indicated in Fig. 1 by 4b  
10 and, in the case of relatively thin profiles, can be wound on a roll 13 with the aid of a winding installation, which is not shown, or, especially in the case of non-windable extrusion profiles, can be cut into pieces of the desired length by means of a cutting installation 14, such as travelling scissors or a travelling knife.

As will be immediately apparent after the following description, the  
15 compression installation 10 can be implemented in diverse ways. The compression installation 10 can also be split into multiple compression installations 10 and arranged in other positions in the line. Although this is less probable, it is possible, for example, to provide a compression installation as early in the line as before the first cooling step. More probably said compression installation can, for example, be incorporated in  
20 the cooling installation 8 or air cooler/dryer 9 or optionally between the cooling installation 8 and cooler/dryer 9.

The extrusion installation, and in particular the extrusion die, is so constructed that a profile such as is shown in Figs 4A, 5A, 6A and 7 is extruded therewith. That is to say the extrusion installation extrudes a single channel tube (Fig. 4A, Fig. 5A) or a  
25 multi-channel tube (Fig. 6A) or a combination thereof (Fig. 7) with ribs 22, 23, 32, 33, 42, 43 projecting into the interior from the inside wall, which ribs thus always have a free end 60. The extrusion profile is then compressed in a compression step such that the external thickness F decreases to G (indicated in Fig. 4A and Fig. 4B). During this operation the free ends 60 of the freely projecting ribs can be brought close to an  
30 opposing interior part of the tube, preferably in contact therewith. In this way a multi-channel tube profile having a multiplicity of channels 27, 28; 37, 38; 47, 48, 49, is then obtained in the compression step or, optionally, the various compression steps.

The extrusion of a single channel or multi-channel profile as shown in Figs 4,

5A, 6A and 7 is relatively simple and can be achieved by the average person skilled in the art in diverse ways in principle. According to the invention this can be achieved in particular by using an extrusion die having, in particular, an extrusion mandrel 16 constructed in accordance with one part of the invention. Said extrusion mandrel 16 is shown in detail for the profile in Fig. 4A in Fig. 3 and is shown in Fig. 2B as part of the male die section 2.

Figs 2A and 2B show, except for the extrusion mandrel 16, an extrusion die which is customary and known per se consisting of a female die section 3 and a male die section 2. The female die section 3 comprises the extrusion gap 15 which defines the outer periphery of the profile from Fig. 4A to be extruded, with, on the feed side of the extrusion gap 15, an enlarged feed chamber 19 via which the material to be extruded, which is under high pressure, is able to flow to the gap 15. The female die section 3 is further provided with dowel pin holes 18 in which dowel pins 17 of the male die section 2 fit in order to be able to fix the male die section 2 in a fixed position with respect to the female die section 3. The male die section 2 comprises a bridge 25, on which the actual extrusion mandrel 16 is mounted, and feed openings 20, along either side of the bridge 25, for plastically deformable material under pressure which is to be extruded.

With reference to, in particular, Fig. 3, it can clearly be seen that the extrusion mandrel 16, referred to simply as the mandrel, for a profile according to Fig. 4A consists of a solid plate-shaped section in which grooves 21 are formed from the underside and grooves 29 are formed from the top. As can clearly be seen, the grooves each have a base extending in the extrusion direction and therefore do not completely intersect the mandrel 16. As a consequence of this, the mandrel 16 acquires a relatively high strength, a long tool life and high resistance to wear. In order to facilitate entry of the material to be extruded into the grooves 21 and 29, these are provided with a widened section 24 upstream. The mandrel 16 can be considered to fit virtually precisely in the interior of the profile shown in Fig. 4A. The grooves 21 form the freely projecting interior ribs 22 and the grooves 29 form the freely projecting interior ribs 23.

As will be clear from Fig. 5A, the grooves to be formed on either side in the mandrel can optionally also be located precisely opposite one another. Furthermore, it will also be clear without any further explanation that the grooves can optionally also

be formed only on one side of the mandrel 16.

Furthermore, it is illustrated with the aid of Fig. 6A that it is also possible within the scope of the invention to make the die mandrel of not entirely solid construction but with, for example, seven mandrel parts separated by run-through slots, each of which mandrel parts, or at least a number of said mandrel parts, being  
5 provided, however, with grooves with a base.

Furthermore, it is illustrated with the aid of Fig. 7 that it is also possible using a single extrusion die, which can easily be produced by a person skilled in the art on the basis of Fig. 7 and with this description at hand, to extrude two or more tubes  
10 which are joined to one another by a connecting web. The tubes can then be subjected together or one by one to a compression step, or just one of the tubes can be subjected to a compression step, in order to obtain one or more multi-channel tubes.

As will be apparent, the double (multi-channel) tube profile in Fig. 7 is made up of a (multi-channel) tube profile according to Fig. 5A and a (multi-channel) tube  
15 profile according to Fig. 6A. However, it will be clear that a double (multi-channel) tube profile can also be produced by using two (multi-channel) tube profiles from Fig. 5A, two (multi-channel) tube profiles from Fig. 6A or two (multi-channel) tube profiles from Fig. 4A. Furthermore, it will be immediately apparent that a very wide variation in multi-channel tube profiles, or at least extrusion dies for the preceding  
20 extrusion profiles that have not yet been compressed, is possible within the scope of the invention.

Figs 8 and 9 show, by way of example, two installations which can be used for compressing a profile, such as, for example, those shown in Figs 4A, 5A, 6A and 7. In Fig. 8 the compression installation consists of top rollers 11 and bottom rollers 12  
25 arranged such that they are offset with respect to the top rollers 11 by half the diameter thereof. A desired reduction in thickness can then be achieved relatively easily by suitable adjustment of the top rollers 11 and bottom rollers 12 with respect to one another.

Fig. 9 shows a variant with top rollers 61 and bottom rollers 62 which are  
30 located precisely opposite one another. Especially in the case of the variant according to Fig. 9, a slit-shaped passage must be formed between the rollers 61, 62 opposite one another by means of a recess 63 in the top rollers 61 and/or bottom rollers 62. The advantage of a recess 63 is in particular also that lateral shifting of the extrusion

profile in the longitudinal direction of the rollers is then prevented.

It will be clear that it is by no means necessary always to use more than one top roller and more than one bottom roller in each thickness reduction step. Especially in the case of the installation according to Fig 9, it is very well conceivable to work with one top roller and one bottom roller in each thickness reduction step.

As an indication of the very fine and flat multi-channel extrusion profiles which can be produced by the method according to the invention, a table is also given below in which the dimensions A, B, C, D, E, F and G, in each case in mm, are indicated by way of example for Figs 4, 5 and 6. It must be understood that even smaller dimensions are possible with the method and installation described above.

TABLE

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>
Fig. 4	0.25	0.7	1.5	0.7	1.57	2.1	1.3
Fig. 5	0.15	0.55	2.1	1.1	0.6	2.7	1.7
Fig. 6	0.4	0.61	2.22	1.22	0.4	3.02	2.02

Claims

1.Method for the production of multi-channel tubes, in particular flat multi-channel tubes, which comprises the following steps:

- 5
- a) forming, by means of extrusion, a tube having on the inside a multiplicity of ribs extending in the longitudinal direction of the tube, projecting from the inside wall of the tube and having free ends;
  - b) compressing the extruded tube to bring the free ends of the internal ribs close to, preferably in contact with, an opposing interior part of the tube such that a
- 10 multiplicity of interior channels are formed in the tube.

2.Method according to Claim 1, wherein aluminium or an aluminium alloy is extruded in step a).

15

3.Method according to one of the preceding claims, wherein a die comprising an extrusion passage defining the outer circumference of the tube and a mandrel defining the internal circumference and internal ribs of the tube is used for the extrusion in step a), wherein the mandrel comprises an essentially solid component with, in the circumferential surface transverse to the extrusion direction, grooves determining the projecting ribs with free ends, the grooves having a base extending in

20 the extrusion direction.

4.Method according to one of the preceding claims, wherein step b) is, at least

25 partially, carried out at an external temperature below 600 °C.

5.Method according to one of the preceding claims, wherein the extruded tube is cooled with a liquid and/or air between step a) and step b).

30

6.Method according to one of the preceding claims, wherein the compression is carried out by feeding the extruded tube between one or more sets of rollers.

7.Method according to one of the preceding claims, wherein the compression is

carried out stepwise in several steps, the temperature falling from each step to the next.

8. Method according to one of the preceding claims, wherein flat multi-channel  
5 tubes are formed comprising channels having a width less than 0.75 mm, such as  
0.45 mm or smaller.

9. Method according to one of the preceding claims, wherein the thickness of  
the projecting ribs is less than 2 mm, preferably less than 0.3 mm, such as, for  
10 example, approximately 0.15 - 0.05 mm.

10. Method according to one of the preceding claims, wherein the height of the  
projecting ribs is less than 6 mm; preferably less than 0.6 mm, in particular 0.2 mm.

11. Method according to one of the preceding claims, wherein the interior  
15 thickness of the tube formed in step a) is greater than the height by which the  
projecting ribs project from the inner wall of the tube formed in step a).

12. Method according to one of the preceding claims, wherein two tubes joined  
20 to one another by a connecting web are formed by extrusion in step a) and wherein at  
least one of said tubes has, on the inside, a multiplicity of said projecting ribs with  
free ends and is subjected to step b).

13. Multi-channel tube, in particular flat multi-channel tube, obtained using the  
25 method according to one of the preceding claims.

14. Multi-channel tube, in particular flat multi-channel tube, made of aluminium  
or an aluminium alloy, for evaporators, condensers and radiators of, in particular,  
vehicles, which multi-channel tube is obtained using the method according to one of  
30 the preceding Claims 1 - 12.

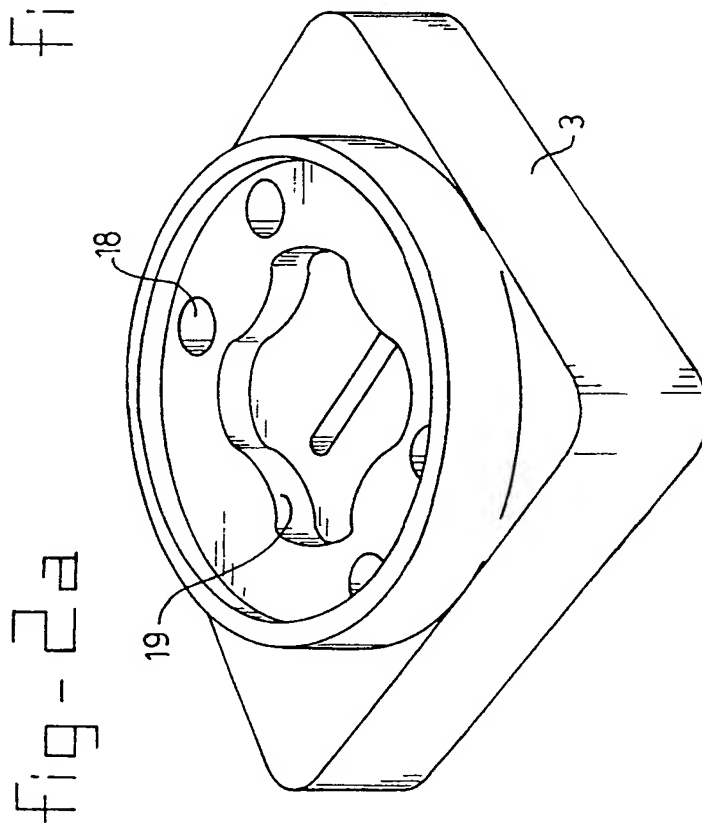
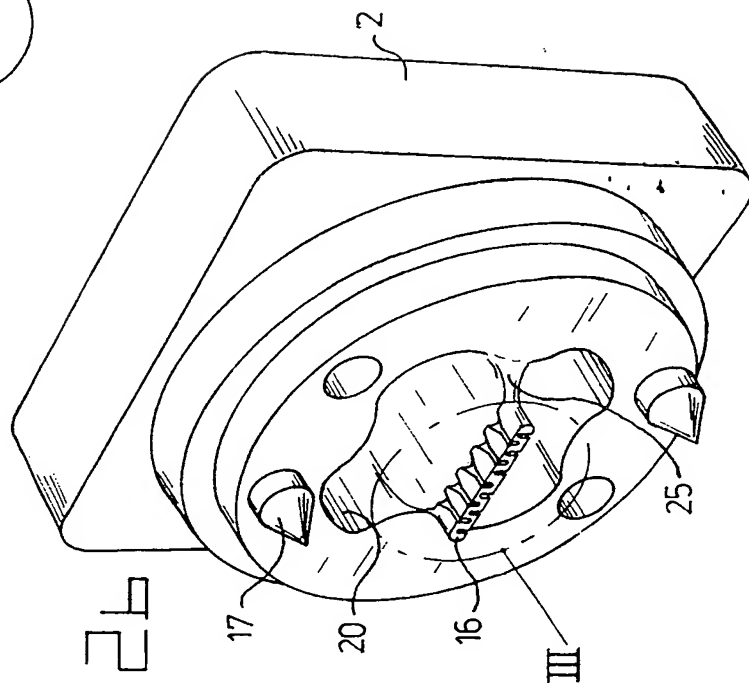
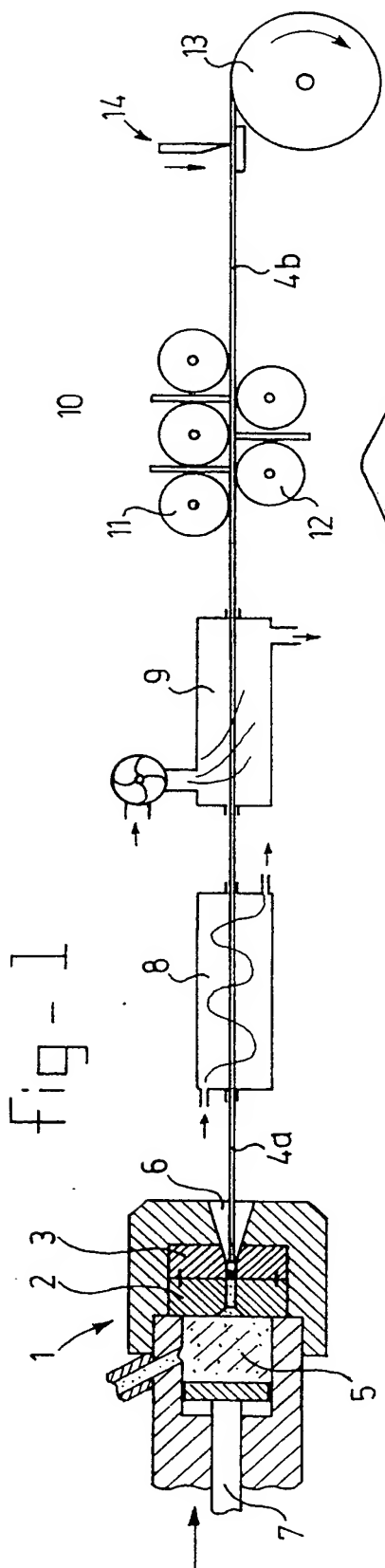
15. Extrusion die for forming, by extrusion, a tube having ribs, with free ends,  
projecting on the inside, comprising an extrusion passage defining the outer

circumference of the tube and a mandrel defining the interior circumference and interior ribs of the tube, wherein the mandrel comprises an essentially solid component with, in the circumferential surface transverse to the extrusion direction, grooves having a base extending in the extrusion direction, in which the grooves define the projecting ribs with free ends.

16. Installation for carrying out the method according to one of Claims 1 - 12, comprising a ram extruder installation having an extrusion die according to, preferably, Claim 15 and compression means.

17. Installation according to Claim 16 wherein the compression means are positioned downstream of the extrusion die.

\*\*\*\*\*





2/4

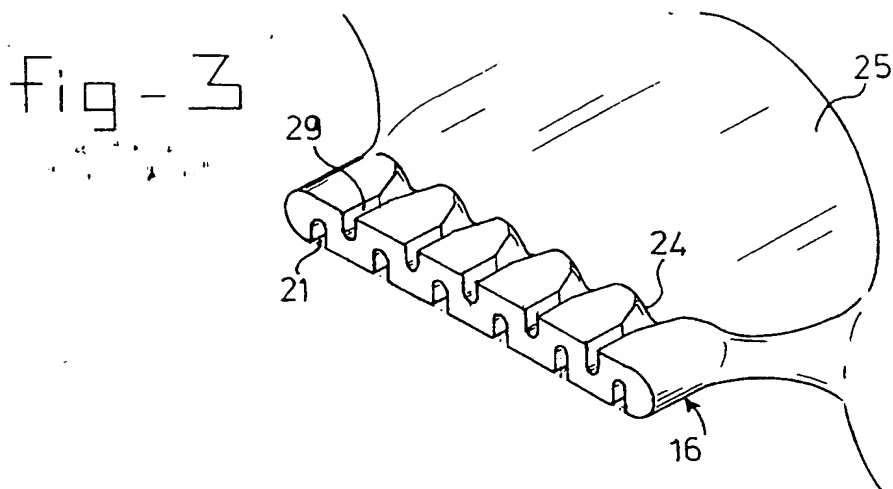


fig-4a

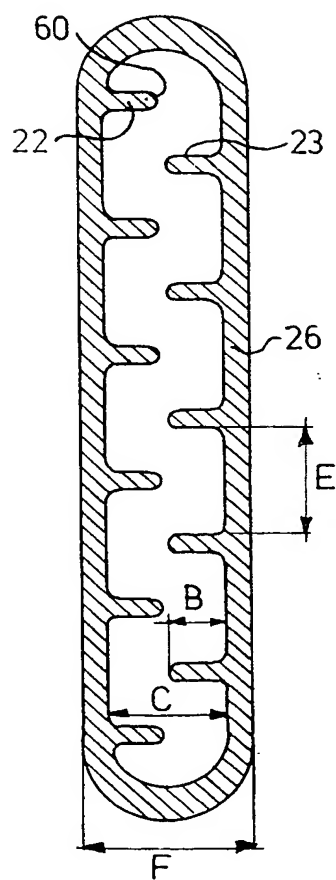


fig-4b

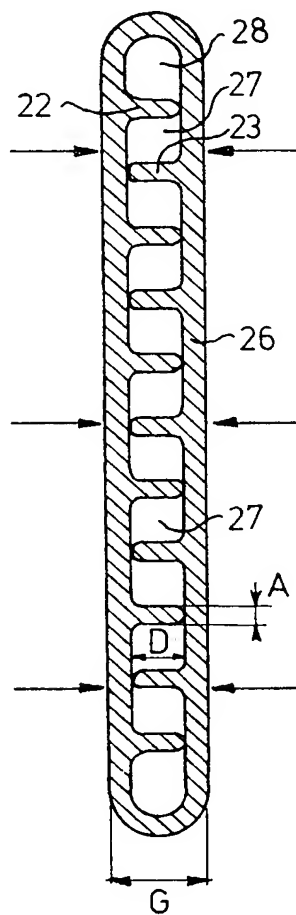


fig - 5a

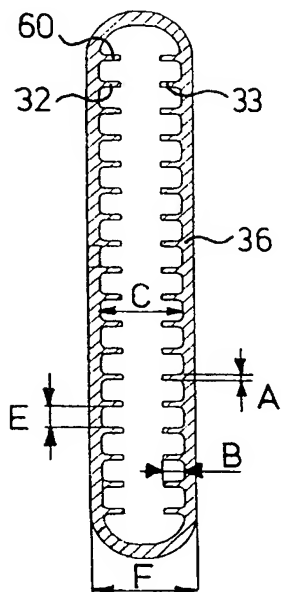


fig - 5b

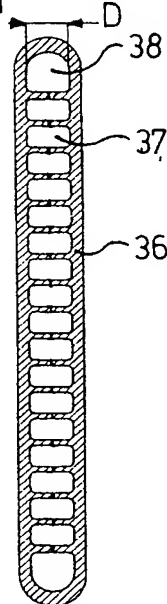


fig - 6a

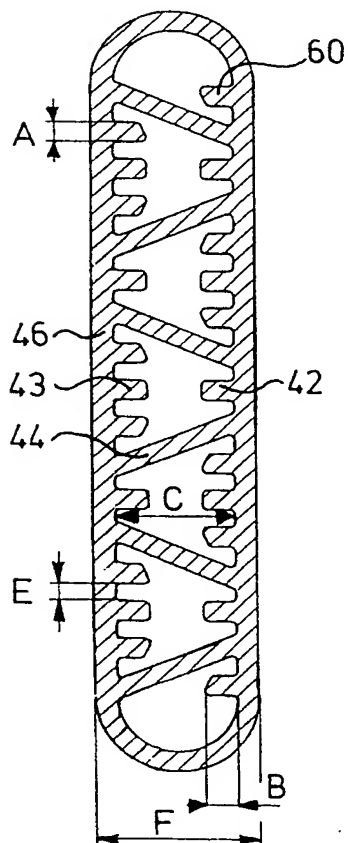
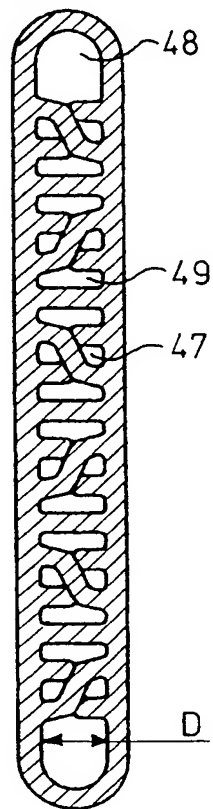


fig - 6b



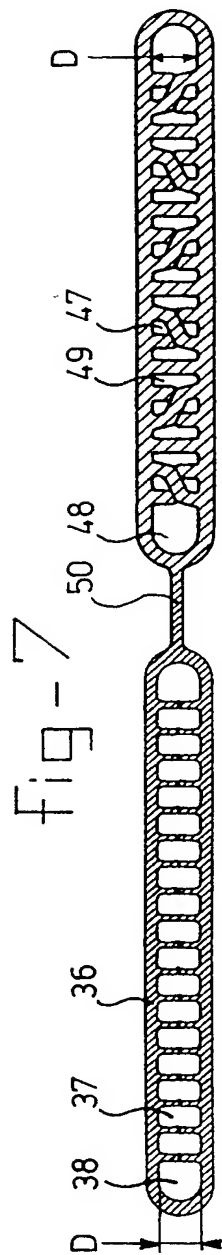


fig - 9

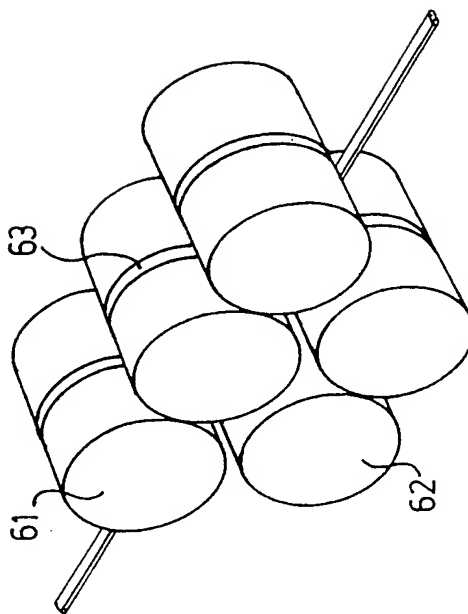
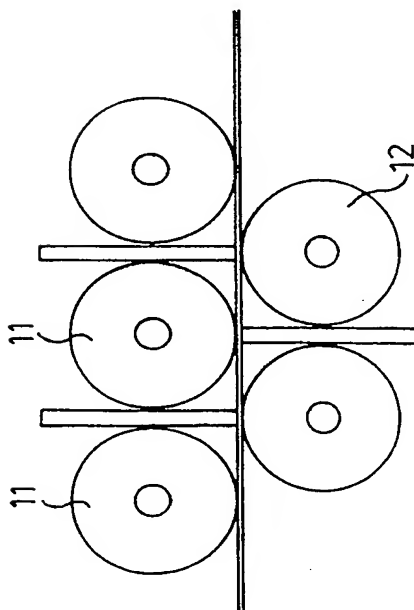


fig - 8



# INTERNATIONAL SEARCH REPORT

Int. l. Application No  
PCT/NL 98/00603

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 B21C37/15 B21C23/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 B21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 306 899 A (NORSK HYDRO AS) 15 March 1989	1-3,6, 10,11, 13,14 15-17
A	see column 4, line 34 - column 5, line 7; claim 1; figures	
X	US 4 204 309 A (LEFRANCOIS JEAN) 27 May 1980 see column 4, line 1 - line 10; claims 2,3; figures	1,3,13
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 347 (M-743), 19 September 1988 & JP 63 108914 A (KOBE STEEL LTD), 13 May 1988 see abstract	1,3,13

-/-

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

**\* Special categories of cited documents :**

"A" document defining the general state of the art which is not considered to be of particular relevance  
"E" earlier document but published on or after the international filing date  
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  
"O" document referring to an oral disclosure, use, exhibition or other means  
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone  
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.  
"&" document member of the same patent family

Date of the actual completion of the international search

30 June 1999

Date of mailing of the international search report

06/07/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

Authorized officer

Barrow, J

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/NL 98/00603

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 110 964 A (MOTOREN TURBINEN UNION) 29 June 1983 see page 1, line 100 - line 112 see page 3, line 110 - line 118; figures ---	1,3,6,13
A	US 3 750 709 A (FRENCH F) 7 August 1973 see column 6, line 12 - line 37; figures 10,11 ---	1,13
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 478 (M-1036), 18 October 1990 & JP 02 192818 A (SHOWA ALUM CORP), 30 July 1990 see abstract -----	1,2,6, 16,17

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. Patent Application No

PCT/NL 98/00603

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0306899	A	15-03-1989	DE 3730117 C	01-06-1988
			AT 70209 T	15-12-1991
			CA 1313752 A	23-02-1993
			CN 1033019 A, B	24-05-1989
			DE 3866830 A	23-01-1992
			JP 1104427 A	21-04-1989
			KR 9606994 B	27-05-1996
			MX 169807 B	27-07-1993
			US 5058266 A	22-10-1991
<hr/>				
US 4204309	A	27-05-1980	FR 2390274 A	08-12-1978
			BE 866467 A	14-08-1978
			BR 7802909 A	26-12-1978
			CA 1102738 A	09-06-1981
			DE 2820828 A	16-11-1978
			GB 1603248 A	18-11-1981
			JP 1313095 C	28-04-1986
			JP 53140387 A	07-12-1978
			JP 60034454 B	08-08-1985
			LU 79653 A	06-11-1978
			NL 7804634 A, B,	15-11-1978
<hr/>				
GB 2110964	A	29-06-1983	DE 3147647 A	16-06-1983
			FR 2517233 A	03-06-1983
			JP 58114827 A	08-07-1983
<hr/>				
US 3750709	A	07-08-1973	US 3662582 A	16-05-1972
<hr/>				

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

☐ BLACK BORDERS

☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES

☐ FADED TEXT OR DRAWING

☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING

☐ SKEWED/SLANTED IMAGES

☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS

☐ GRAY SCALE DOCUMENTS

☒ LINES OR MARKS ON ORIGINAL DOCUMENT

☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY

☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**

**This Page Blank (uspto)**